

A Note on some Photometric Experiments connected with the Application of the Law of limiting Apertures to small Object-glasses. By Edmund J. Spitta.

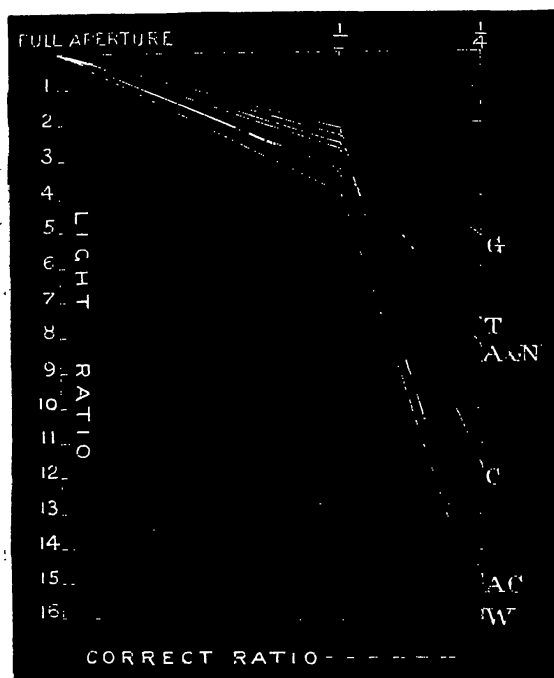
Whilst carrying out some experiments connected with the paper read before the Society in November last, certain doubtful and equivocal results immediately followed the application of a diaphragm to the telescope in use, and these were of so pronounced a character that the use of such means for reducing the intensity of the luminant had to be abandoned. It was known a doubt had always existed as to whether the intensity of a point of light viewed at the focus of a refracting telescope would, when photometrically tested, be found to vary as the square of the linear aperture of the object-glass; in other words, whether it was scientifically accurate or strictly philosophical, seeing its compound nature and its different mode of manufacture, to apply to an object-glass what is generally known as the law of limiting apertures.

Having, therefore, tested photometrically the different zones of this object-glass, and proved that the law (anyhow, with the telescope in question) was *not* applicable, it was thought it would be of interest, seeing the subject had not received any extended investigation, to photometrically test objectives of different makers' manufacture, both English and foreign. Although at present I have only been able to examine telescopes of small aperture, the results furnish me with figures so different, although all in the same direction, that it has been suggested it would be of interest to publish this preliminary note.

In the accompanying table the first column gives the distinguishing name of the object-glass examined; the second and third its aperture and focal length; whereas the fourth and last set forth the actual ratios photometrically obtained, when the aperture was lineally reduced to one-half and one-quarter respectively.

Table of Ratios photometrically obtained.

		inches.	inches.		
I.	Alvan Clark	6.5	93	..... I : $\frac{1}{3.35}$	..... I : $\frac{1}{14.84}$
II.	Tulley	3.1875	46.5	..... I : $\frac{1}{3.3}$	..... I : $\frac{1}{7.5}$
III.	Clerkenwell	2.625	42	..... I : $\frac{1}{2.63}$	..... I : $\frac{1}{11.70}$
IV.	Watson	2.8125	41	..... I : $\frac{1}{2.11}$	..... I : $\frac{1}{15.91}$
V.	Grubb	2.875	40.8	..... I : $\frac{1}{2.31}$	..... I : $\frac{1}{5.07}$
VI.	A. and N.	2.375	24.75	..... I : $\frac{1}{2.47}$	..... I : $\frac{1}{8.23}$



On examination both the table and the diagram show that in all cases, except perhaps that of the object-glass by Alvan Clark, the rays passing through the outer zones do not contribute to the intensity of the focal image as much as theoretically they should. It would seem, too, that focal length is not a factor of importance, as the resulting ratios, although all in the same direction appear to be different in each case, even when the dimensions are nearly similar. But I submit, however, that a solution of the difficulty very possibly lies in the aplanatisation of the respective glasses. With any of the modifications of the zonal treatment it is not difficult to understand that in some instances perfection of definition at the focus has not arisen from a combination of those rays of the spectrum selected by the optician to be united from *all parts* of the object-glass, but has been effected, unconsciously it may be in some cases, by pushing the focus of the rays from the outer zones aside, so as to be finally lost or cut off by suitable diaphragms. This is much the same as when the artist in achromatising neglects the rays from the extreme ends of the spectrum, or permits their focus to be at some place other than that occupied by the visual focus. If the object-glasses I examined were made somewhat in this way, it is easy to perceive how it came about that the application of a large diaphragm, *i.e.* one of large aperture placed between them and the source of light, did not appropriately reduce the brilliancy of the image at the focus. In other words, it would be evident the reason the large diaphragms had not affected the resulting ratios in a manner they should was due to the fact that they were placed over

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portions of each object-glass, which only contributed in a slight degree to the intensity of the image at the focus.

This suggestion, which I venture to submit for the consideration of those better versed in practical optics, was forced upon me by the peculiar phenomena displayed by one of the telescopes I purposely examined photometrically with diverging light (which, of course, very much exaggerated the true state of things). I was surprised to find, when all the internal diaphragms were removed, that the rays from the outermost zone had a focus very sensibly different in length to those from the neighbouring and central ones. Yet the object-glass, when examined as set in its tube, had given much satisfaction in defining powers, going in and out of focus with considerable rapidity. Of course, the use of truly parallel rays, such as are received from a star, would, and indeed were, on trial, actually found to materially alter this state of things, but it was the fact itself that seemed of some importance, as it appeared to me to point in what direction it might be possible to find a solution capable of explaining the different figures that resulted when the law of limiting apertures was applied to the several object-glasses I had examined. It was thought, too, that this explanation would offer a suggestion how it came about that Dr. V. L. Charlier, in *Publications of the Astronomical Society of the Pacific*, No. 17, had actually seemed to prove that the use of diaphragms did not in his telescope control the photographic intensity of a point of light according to theoretical considerations.

Again, too, if such reasoning be true, it is not difficult to see why half the linear aperture of a large telescope has so often been noticed to reveal fainter stars than the full aperture of another of the same linear dimensions.

Another experiment was tried which is of sufficient negative interest to merit being recorded. It was suggested that the peculiar figures of the table perhaps resulted for the most part from differences in the angles of incidence at which the cylindrical beam received from a star impinged upon different zones of the curved anterior surface of each objective respectively. Accordingly, the Clerkenwell object-glass was reversed in its cell so that the posterior surface of its flint glass, which was sensibly flat, should receive the rays from the source of light; but it was found that the ratios did not differ more than by a reasonable observational error from those given in the table, which were obtained with the objective in its normal position.

It is, perhaps, worth mentioning, that on studying the literature of the subject, I find I am not alone in obtaining the peculiar figures of the table, for Dr. Müller, of Potsdam,* working with a Zöllner photometer, reduced his aperture in such

* *Publicationen des Astrophysikalischen Observatoriums zu Potsdam—Photometrische Untersuchungen.*

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ratios that the computed values of the logarithms of brilliancy of a star were:—

1.0742
0.7959
0.4437

but the observed ratios were:—

0.3695
0.3439
0.2687

He remarks, therefore, that the rays coming through the outer parts of his object-glass had very little effect on the brilliancy of the image; and it was only when the diameter had been diminished, say about one half, that the observed and computed ratios had a tendency to agree. But, he adds, that with a larger telescope of 135 mm. aperture—that is, about five and a quarter inches—the difference between the observed and computed ratios became almost nil. This corresponds very approximately with my own experience.

Wolff,* too, after conducting several experiments with an object-glass of 37.4 mm. diameter, comes to much the same conclusion, although, as a matter of fact, I am not able to find that he carried his investigation any further with telescopes of larger proportions.

As it has been pointed out to me, the value of the figures in the table would be increased by giving some of the actual wedge-readings; I select the two sets from which the mean values of the performance of the Grubb objective have been obtained, because they were taken on two different nights. When these are reduced it has been found that the resulting ratios do not differ *inter se* by a quantity much greater than .1 magnitude.

Full ap.	$\frac{1}{2}$ ap.	$\frac{1}{4}$ ap.	Full ap.	$\frac{1}{2}$ ap.	$\frac{1}{4}$ ap.
3.19	1.40	0.33	4.30	2.29	0.65
3.23	1.75	0.32	3.75	2.32	0.82
3.23	1.60	0.29	3.63	2.47	0.80
3.20	1.48	0.33	3.85	2.47	0.75
3.23	1.53	0.5	3.73	2.30	0.64
		0.39		2.40	
M. 3.21	1.55	0.36	3.85	2.37	0.73

It will be noticed that on two occasions six observations were accidentally taken instead of five.

1891 November.

* *Photometrische Beobachtungen an Fixsternen*, 1878, pages 20–22.